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Abstract

Objective To investigate whether a dog's superior olfactory sensitivity can be used to detect *Clostridium difficile* in stool samples and hospital patients.

Design Proof of principle study, using a case-control design.

Setting Two large Dutch teaching hospitals.

Participants A 2 year old beagle trained to identify the smell of *C difficile* and tested on 300 patients (30 with *C difficile* infection and 270 controls).

Intervention The dog was guided along the wards by its trainer, who was blinded to the participants' infection status. Each detection round concerned 10 patients (one case and nine controls). The dog was trained to sit or lie down when *C difficile* was detected.

Main outcome measures Sensitivity and specificity for detection of *C difficile* in stool samples and in patients.

Results The dog's sensitivity and specificity for identifying *C difficile* in stool samples were both 100% (95% confidence interval 91% to 100%). During the detection rounds, the dog correctly identified 25 of the 30 cases (sensitivity 83%, 65% to 94%) and 265 of the 270 controls (specificity 98%, 95% to 99%).

Conclusion A trained dog was able to detect *C difficile* with high estimated sensitivity and specificity, both in stool samples and in hospital patients infected with *C difficile*.

Introduction

Clostridium difficile infection is common, particularly in people in healthcare facilities who have received antimicrobials. *C difficile* causes toxin mediated intestinal disease, with symptoms ranging from mild diarrhoea to severe pseudomembranous colitis and toxic megacolon. The bacterium can be transmitted through either personal contact or the environment.[1] Since 2000 more frequent and severe disease has emerged and large outbreaks in hospitals have necessitated ward closures and extensive infection control measures.[2 3 4] Infection rates seem to be higher in North America than in Europe.[3 5] In the Netherlands the incidence of nosocomial *C difficile* infection is comparable to that of other European countries (mean incidence 17.5-23/10 000 admissions)[6] [7]; the mean incidence in the United Kingdom is 50/10 000 admissions.[6]

Cliff has been trained to sniff out the bacteria clostridium difficile

Early and rapid identification of *C difficile* infection is important for the initiation of infection control measures and treatment to prevent transmission.[8] Several combinations of tests are used to diagnose cases. The traditional standard is by cytotoxin assay, which if *C difficile* toxins are present shows cytotoxicity of faecal eluate on mammalian cells. This technique requires cell cultures, however, and results take at least 1-2 days.[9] [10] Culture on selective media is very sensitive but also time consuming and it lacks specificity because of possible carriage of non-toxigenic isolates. Cultured strains can subsequently be tested for the production of toxins, in which case this is referred to as a toxigenic culture.[4] [10] Easy and rapid enzyme immunoassays to detect *C difficile* toxins or antigens are often used, despite their limited sensitivity or specificity.[10] [11] More recently, several nucleic acid amplification tests have been developed that have a high diagnostic accuracy and short turnaround time, although these tests are expensive and require specialised equipment and expertise.[4] [10] [11] [12]

In daily practice, several factors delay the identification of *C difficile* infections. These include doctor's delay (for example, the doctor does not consider the possibility of a *C difficile* infection, or decides to wait and see if the symptoms pass), inefficient sampling, and time required to process samples in the laboratory.[13] [14] As a result the mean time from onset of symptoms to start of treatment in studies ranges from 2.8 to 7.7 days.[13] [14] This can result in spread of *C difficile* infection by delaying appropriate infection control measures such as transferring patients to a single room. Screening all hospital patients at regular intervals could theoretically prevent delays in diagnosis but this is costly and impractical.

In the 1970s *C difficile* was identified as the cause of pseudomembranous colitis.[15] [16] Since then, *C difficile*associated diarrhoea has often been described as having a characteristic smell.[17] Sensitivity and specificity of the odiferous detection of *C difficile* by nursing staff are 55-82% and 77-83%, respectively.[18] [19] Dogs have a far superior sense of smell, however, which is thought to exceed that of humans by a factor of 100.[20] We hypothesised that it may be possible for a dog to be trained to recognise the presence of *C difficile* in stool samples, or even in patients. If so, this could prove a valuable screening tool for *C difficile* infections in healthcare facilities.

Methods

The training process

The dog used in this study was a 2 year old male beagle (fig 1⇓). A professional detection dog instructor (HL) trained the dog to identify *C difficile* in stool samples and, if this proved possible, in patients. A reward based training method was used in which the correct behaviour was reinforced, for instance by providing a treat. The dog was taught to sit or lie down if a specific scent was detected. He had not received previous training in detection.